Please add new Claims 23-24.

23. (New) A magnetic field sensor comprising a magnetostrictive material in contact with a piezoelectric material, the sensor having a field sensitivity larger than approximately 10 mV/Oe.

24. (New) A magnetic field sensor as described in claim 8, wherein the magnetostrictive material is a metal alloy.

REMARKS

Information Disclosure Statement

An Information Disclosure Statement (IDS) is being filed concurrently herewith. Entry of the IDS is respectfully requested.

With the entry of the foregoing amendment, claims 6-21, 23 and 24 remain in this case. Claims 1-5 and 21 have been cancelled. Claims 6-14, 16, 18, 20 have been amended, and new claims 23 and 24 have been added to alternatively characterize the invention.

In the Office Action dated February 23, 2001, the Examiner objected to the title as not descriptive of the invention. Applicant respectfully submits that the title is adequately descriptive of the present invention, which relates generally to passive, solid-state magnetic field sensors, and the uses for such devices.

The Examiner also objected to the drawings as not showing every feature of the claimed invention. Applicant believes that with the entry of the amendment, this rejection is moot.

The Examiner rejected claims 1-22 under 35 U.S.C. §112, second paragraph, for indefiniteness. It is believed that the amended and new claims define the subject invention with the requisite degree of clarity and precision. Specifically regarding the Examiner's rejection of claim 16, the meaning of a patterned stripe of piezoelectric material is sufficiently clear to one of ordinary skill in the art, particularly with reference to the applicant's disclosure (*See, e.g.,* Specification, page 10, line 16; Figs. 3a, 3b).

The Examiner rejected claims 1-4, 8, 9, 10, 14-17, 20 and 22 under 35 U.S.C. §102(b) as being anticipated by Oetzmann, GB 2188157, or, alternatively, by Kinsner, U.S. Patent No. 3,909,809.

Applicant draws the Examiner's attention to the outstanding claims, and in particular, to independent claim 8. As illustrated by claim 8, the magnetic field sensors of the present invention generally comprise a multilayer material, where the multilayer material comprises at least one layer of magnetostrictive material in contact with one layer of piezoelectric material. During operation, the magnetostrictive material strains under the influence of an external alternating magnetic field. This strain induces mechanical stress on the piezoelectric material, thus producing a detectable voltage signal that is indicative of the external alternating magnetic field.

Independent claim 8 has been amended to clarify certain features of the present magnetic field sensors. More particularly, the magnetic field sensors are characterized in that, when the magnetostrictive material is subjected to an *alternating magnetic field*, a change in at least one dimension of the magnetostrictive material induces a strain in, and produces a detectable non-zero voltage signal in, the piezoelectric material. In general, the present invention is directed to magnetic field sensors for alternating (i.e. ac) magnetic fields.

Moreover, claim 8 has also been rewritten to highlight another feature of the present invention, namely, the fact that the sensors of the present invention are *passive* magnetic field sensors. As recited by claim 8 and its dependents, the sensors of the present invention are additionally characterized in that, during operation, the sensors do not consume any external electrical power. This is an advantage of the present invention relative to prior art magnetic field sensors, which rely on external power to, for instance, drive a piezoelectric resonator to create a standing stress wave in the sensing magnetostrictive ribbon, or provide an ac electrical current to a solenoid surrounding the sensor.

Oetzmann, GB 2188157, relates to a magnetic sensor arrangement comprising a piezoelectric member secured to a magnetostrictive member, wherein the magnetic sensor arrangement additionally comprises a solenoid into which the sensor is placed, and during operation, an alternating current is supplied to the solenoid by an external source. (*See, e.g.*, page

1, line 129 through page 2, line 6). Unlike the present claims, Oetzmann fails to teach or suggest a magnetic sensor arrangement that does not rely on external electrical power during operation.

Oetzmann does discuss a magnetic sensor design that utilizes magnetostrictive material in contact with piezoelectric material. However, as noted on page 1, lines 17-24 and 121-128, the "simple dc sensor arrangement" described suffers from a number of deficiencies, including build up of excess charge, thermal expansion of the strips, and drift in the piezoelectric strip. This reference further instructs that this arrangement is "noisy and stable in operation," and that these deficiencies can be overcome by the addition of the solenoid and external source arrangement as described above. The reference actually teaches away from a magnetic field sensor that does not consume any external electrical power during operation.

Moreover, the sensor arrangement disclosed in Oetzmann relates to a magnetic sensor for a non-alternating (i.e. dc) external magnetic field, (*See, e.g.*, page 1, line 121, page 2, lines 57-59), and neither teaches nor suggests a magnetic field sensor for detecting an alternating external magnetic field.

Kinsner, US 3,909,809, similarly fails to teach or suggest the novel magnetic field sensors of the present claims. This reference relates specifically to magnetic bubble-domain sensing devices, and does not teach the general applicability of magnetostrictive and piezoelectric materials for magnetic field sensing. This reference further fails to teach or suggest magnetic field sensors for detecting an alternating external magnetic field, and is limited to the specific application of determining the presence of a bubble directly underneath, and in contact with, the sensing element. (*See, e.g.*, col. 3, lines 47-49; Fig. 2).

For the reasons stated above, Applicant believes that claim 8 and its dependents are in condition for allowance.

The Examiner further rejected claims 5-7, 11-13, 18, 19 and 21 under 35 U.S.C. §103(a) as being unpatentable over Oetzmann, or, alternatively, Kinsner. As understood, it is apparently the Examiner's contention that magnetostrictive/piezoelectic material for magnetic field sensing is known, therefore all designs and/or applications utilizing a combination of magnetostrictive and piezoelectic materials are obvious. Applicant respectfully submits that the Examiner has not satisfied his burden in establishing *prima facie* obviousness.

More specifically, the present claims 6, 7, 11, 20 and 21 recite particular applications for piezoelectric/magnetostrictive magnetic field sensors, including rotor movement detection, fluid flow detection, electrical current detection, reading stored information from recorded media, and an MRAM device. The Examiner has not cited to any prior art disclosing a combination of piezoelectric/magnetostrictive material that suggests adapting such a structure for use in any such application, (such as an MRAM device), how such a structure might be adapted for such use, or the desirability of adapting a piezoelectric/magnetostrictive combination for such use. Nor has the Examiner cited to any prior art disclosing previously known fluid flow detection systems, electrical current detectors, RAM devices, etc., that could provide a suggestion to adapt a combination piezoelectric/magnetostrictive structure for any of these uses.

Regarding claim 12, the Examiner has failed to demonstrate where in the art it is taught or suggested that the sensitivity of the sensor is dependent on the area of the layers.

Regarding claim 13, the Examiner has failed to demonstrate where in the art is taught or suggested a magnetostrictive/piezoelectric magnetic field sensor that is cantilevered to increase the strain on the piezoelectric material, and thus improve sensitivity.

The Examiner has also failed to demonstrate where in the art it is suggested to utilize a ferrite for the magnetostrictive material, or a magnetic field sensor comprising a substrate of magnetostrictive material, or a magnetic field sensor comprising a substrate of magnetostrictive material wherein the piezoelectric material comprises one or more strips patterned onto the substrate. As discussed on page 10, line 10, *et seq.*, a planar design lends itself to thin-film processing, and has the additional advantages of a high length-to-area ratio to give a small capacitance that permits high-frequency operation.

The applicant has added two new claims to alternatively characterize the invention. Claim 23 recites that the magnetic field sensor comprises a magnetostrictive material in contact with a piezoelectric material, wherein the sensor has a field sensitivity of larger than 10 mV/Oe (*See, e.g.*, Speification, page 3, line 4). New claim 24 depends from claim 8, and recites a magnetic field sensor according to the present invention wherein the magnetostrictive material is a metal alloy (*See*, *e.g.*, Specification, page 9, line 21 to page 10, line 9).

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned at (781) 861-6240.

Respectfully submitted,

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MARKED UP VERSION OF AMENDMENTS

Claim Amendments Under 37 C.F.R. § 1.121(c)(1)(ii)

6. (Amended) A magnetic field sensor [system for detecting] as described in Claim 8, wherein the detectable voltage signal is indicative of the rotation of a rotor [movement comprising a magnetic field sensor having magnetorestrictive and piezo electric materials].

7. (Twice Amended) A [system] sensor as described in Claim 6, wherein the rotation of the rotor is [used as a flow speed detector] indicative of a fluid flow, where the magnetic rotor is located in the flow path of, and is turned by, the flow of the fluid.

8. (Amended) A magnetic field sensor comprising a multilayer material, the multilayer material comprising [about one] a layer of a magnetostrictive material in contact with a layer of a piezoelectric material, and the multilayer material configured such that, when the magnetostrictive material is subjected to an alternating magnetic field, a change in at least one dimension of the magnetostrictive material induces a strain in, and produces a detectable voltage signal in, the [that strains under the influence of a magnetic field and imparts stress to about one layer of] piezoelectric material [to produce a detectable voltage], and wherein during operation the magnetic field sensor does not consume any external electrical power.

9. (Amended) [An electromagnetic] The magnetic field sensor as described in Claim 8, wherein the [sensor consists essentially of two layers] multilayer material comprises a second layer of magnetostrictive material [sandwiching one] positioned so that the layer of piezoelectric material lies between the two layers of magnetostrictive material.

10. (Amended) [An electromagnetic] The magnetic field sensor as described in Claim 8, wherein the [sensor consists essentially of two layers] multilayer material comprises a second layer of piezoelectric material [sandwiching one] positioned so that the layer of magnetostrictive material lies between the two layers of piezoelectric material.

11. (Amended) A magnetic field sensor as described in Claim 8, wherein the [sensor is utilized to measure] detectable voltage signal is indicative of an electrical current in an electrical conductor.

12. (Amended) A magnetic field sensor as described in Claim 8, additionally comprising a high impedence readout circuit, connected to the layer of piezoelectric material, wherein a sensitivity of the sensor is proportional to a thickness of the piezoelectric layer and substantially independent of [an] a surface area of the [sensor when a high impedance readout circuit is used] multilayer material.

13. (Amended) A magnetic field sensor [comprising at least one layer of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to at least one layer of piezoelectric material to produce a detectable voltage] as described in Claim 8, wherein the sensor is supported as a cantilever in which one end of the sensor is allowed to strain freely to thereby increase the sensitivity.

14. (Amended) A magnetic field sensor [comprising at least one layer of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to at least one layer of piezoelectric material to produce a detectable voltage] as described in Claim 8, wherein the layer of magnetostrictive material [forms] comprises a substrate.

16. (Amended) A magnetic field sensor [comprising a substrate of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to] as described in Claim 14, wherein the layer of piezoelectric material comprises at least one patterned stripe of electrically insulating piezoelectric material [to produce detectable voltage].

18. (Amended) A magnetic field sensor as described in Claim 16, [further comprising multiple, series connected] wherein the layer of piezoelectric material comprises at least two stripes of piezoelectric material connected electrically in series.

20. (Amended) A magnetic field sensor as described in Claim 8, wherein the multilayer material comprises a read head [comprising a magnetostrictive material that strains under the influence of a magnetic field and imparts stress to a piezoelectric material to produce a detectable voltage] for reading stored information on a recording medium.